Uddeholm
Skolvar®

UDDEHOLM
a voestalpine company

Uddeholm Skolvar®

Uddeholm offer a wide range of high-quality hot forming material for superior performance in a variety of applications. The unique forging grade Uddeholm Skolvar is designed to withstand extreme heat, pressure, and wear, making it ideal for the most demanding hot forming applications. To improve the heat resistance of hot forming dies and reduce the risk for wear, manufacturers may use high-performance materials such as Uddeholm Skolvar. This material has excellent thermal stability and can withstand the high temperatures and load involved in the forming process.

GENERAL

Uddeholm Skolvar is an ESR-premium Cr-Mo-V-alloyed tool steel characterized by:

- very good hot-wear resistance
- very good resistance to abrasive wear
- good ductility
- very good resistance to tempering back
- very good cleanliness
- possible to heat-treat to 50-61 HRC
- very good hardenability
- good machinability and grindability

Typical analysis %	C 0.7	Si 0.2	Mn 0.45	Cr 5.0	Mo 2.25	V 1.6
Standard specification	None					
Delivery condition	Soft-annealed. Hardness ≤ 229 HB					
Colour code	Red/Black					

APPLICATIONS

Uddeholm Skolvar is suitable for hot/press-forging and hot-stamping where hot wear is the predominant failure mechanism. Special applications in extrusion and e.g. “shot sleeves” in die-casting are other areas where Uddeholm Skolvar’s excellent properties are favourable. The properties of Uddeholm Skolvar makes it also suitable for other applications such as cold work and components.

PROPERTIES

The physical and mechanical properties below are representative of samples which have been taken from the centre of bars with dimension 300 x 150 mm (11.8” x 5.9”). Unless otherwise indicated all specimens have been hardened at 1050°C (1922°F), gas quenched in a vacuum furnace and tempered three times at 560°C (1040°F) for two hours; yielding a working hardness of 56±1 HRC.

PHYSICAL PROPERTIES

Temperature	20°C (68°F)	500°C (932°F)	600°C (1112°F)
Density Kg/m³ Lbs/in³	7760 0.280	7630 0.276	7600 0.274
Modulus of elasticity MPa psi	208 000 30.2 x 10^6	171 000 24.8 x 10^6	154 000 22.3 x 10^6
Coefficient of thermal expansion per °C from 20°C per °F from 68°F	-	12.8 x 10^{-6} 7.1 x 10^{-6}	13.2 x 10^{-6} 7.3 x 10^{-6}
Thermal conductivity W/m °C Btu in/ (ft2h°F)	27 187	29 201	29 201
Specific heat J/kg°C Btu/lb°F	478 0.11	641 0.15	737 0.18

MECHANICAL PROPERTIES

Approximate tensile strength at room temperature

Hardness	51 HRC	56 HRC	59 HRC
Yield strength, Rp0,2	1490 MPa	1790 MPa	2030 MPa
Tensile strength, Rm	1750 MPa	2110 MPa	2350 MPa
Elongation, A5	7 %	4 %	2 %
Reduction of area, Z	25 %	7 %	0 %

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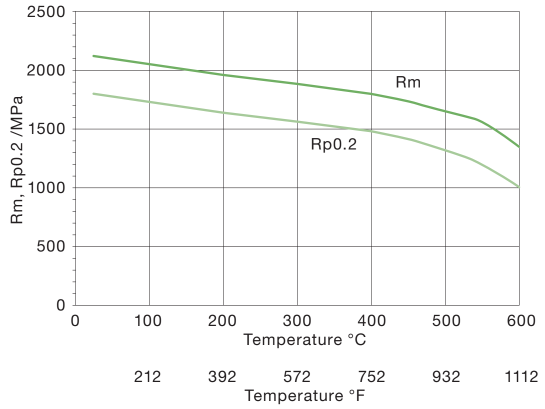
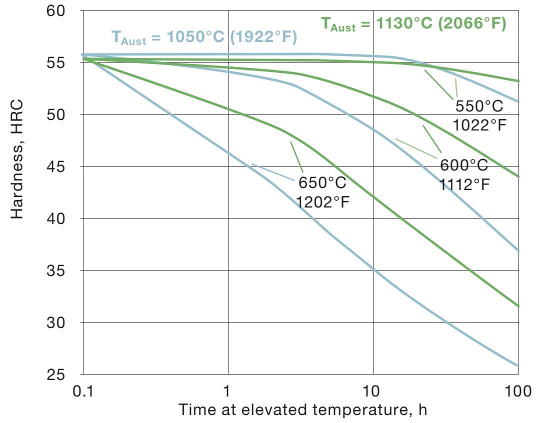
APPROXIMATE TENSILE STRENGTH AT ELEVATED TEMPERATURES

Hardness 56±1 HRC
Austenitizing temperature 1050°C (1922°F), tempering temperature 560°C (1040°F) 3x2h



EFFECT OF TIME AT HIGH TEMPERATURES ON HARDNESS

Initial hardness: 56±1 HRC
Austenitizing temperature: 1050°C (1922°F) vs 1130°C (2066°F)



HEAT TREATMENT – GENERAL RECOMMENDATIONS

Soft annealing
Protect the steel and heat through to 850°C (1560°F). Then cool in furnace at 10°C (20°F) per hour to 600°C (1110°F), then freely in air.

Stress relieving
After rough machining the tool should be heated through to 650°C (1200°F), holding time 2 hours. Cool slowly to 500°C (930°F), then freely in air.

Hardening
Preheating temperature: 600–650°C (1110–1200°F) and 850–900°C (1560–1650°F).

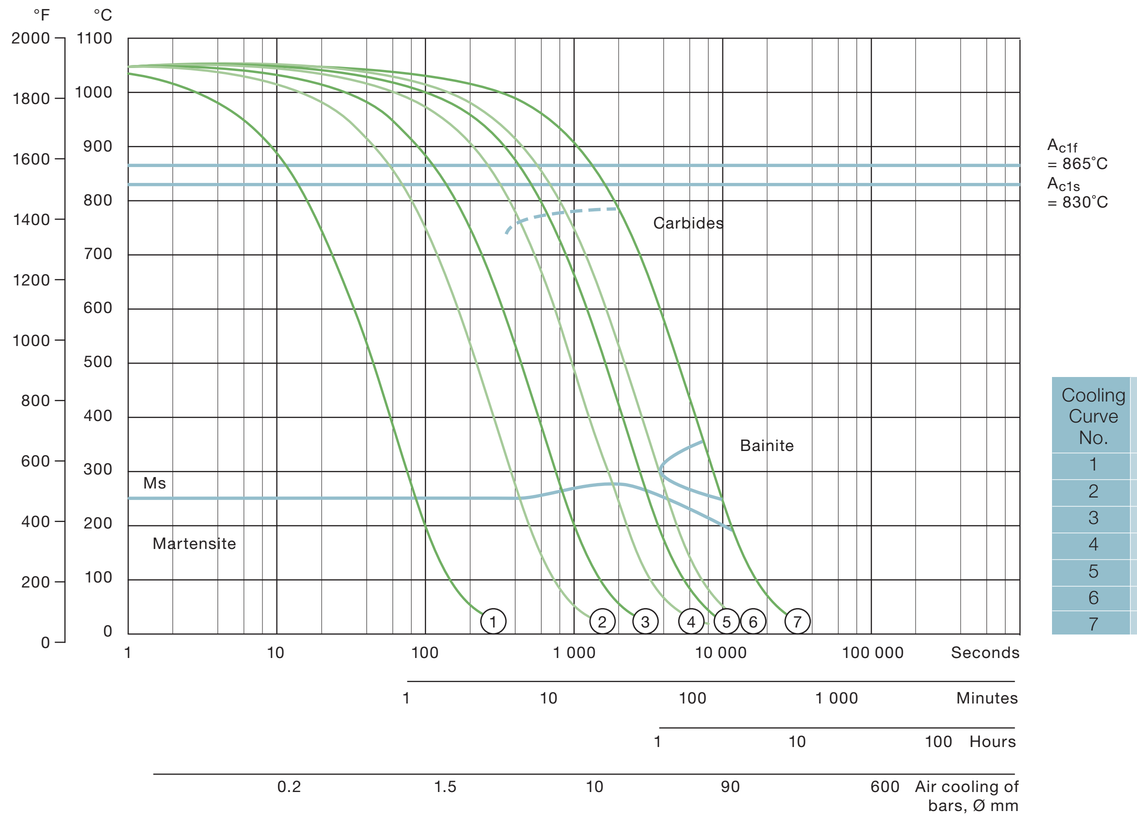
Austenitizing temperature: 1050–1150°C (1920 - 2100°F), normally 1050°C (1920°F) or 1130°C (2066°F).

Holding time: 30 minutes (<1100°C) or 10 minutes (≥1100°C).

Protect the tool against decarburization and oxidation during austenitizing.

CCT GRAPH

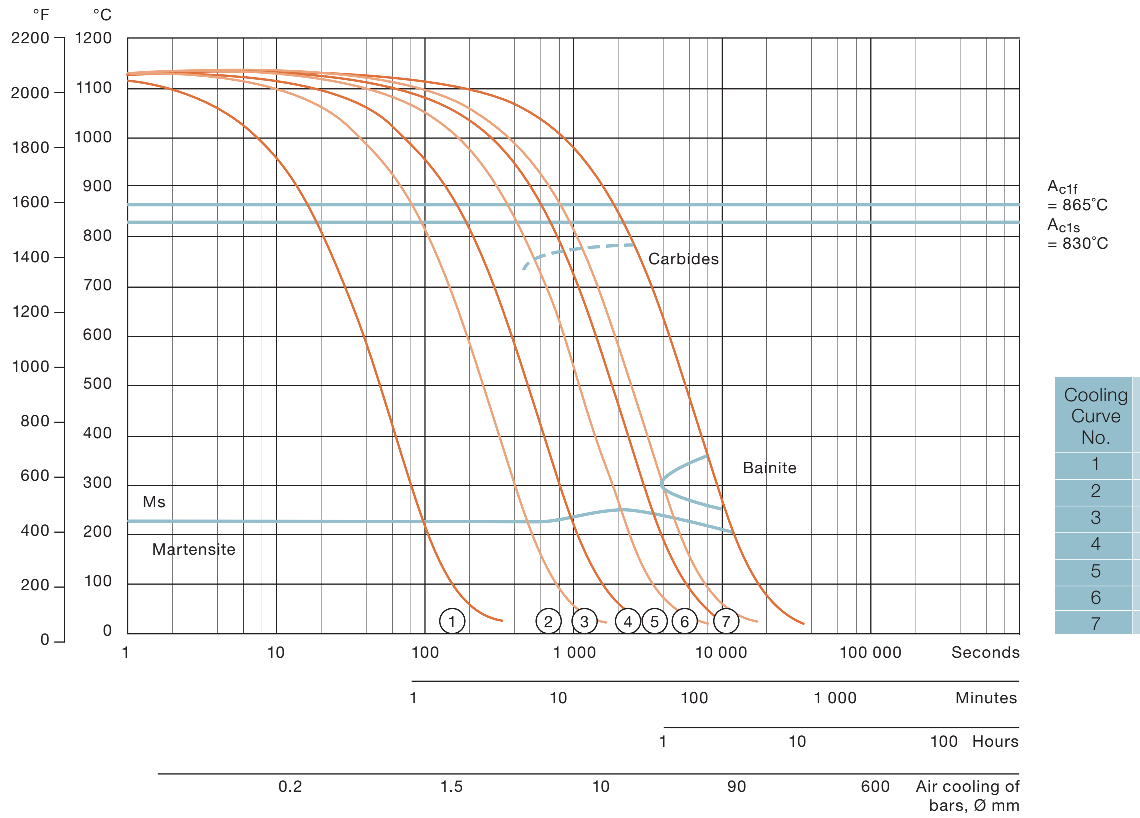
Austenitizing temperature 1050°C (1922°F). Holding time 30 minutes.



Cooling Curve No.	Hardness HV10	$T_{800-500}$ (sec)
1	782	28
2	781	140
3	755	280
4	718	630
5	711	1030
6	726	1390
7	6606	3205

CCT GRAPH

Austenitizing temperature 1130°C (2066°F). Holding time 10 minutes



Cooling Curve No.	Hardness HV10	$T_{800-500}$ (sec)
1	806	28
2	812	140
3	804	280
4	800	630
5	764	1030
6	750	1390
7	638	3205

QUENCHING MEDIA

- High speed gas/circulating atmosphere
- Vacuum furnace (high speed gas with sufficient overpressure)

Note: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

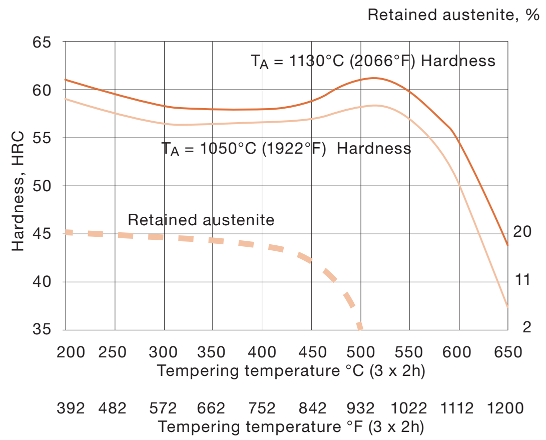
To obtain the optimum properties for the tool, the cooling rate should be as fast as possible with regards to acceptable distortion.

A slow quench rate will result in loss of hardness compared with the given tempering curves.

TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph below.

Temper at least twice with intermittent cooling to room temperature. High temperature tempering >525°C (980°F) is recommended whenever possible.



DIMENSIONAL CHANGES DURING

HARDENING AND TEMPERING

During hardening and tempering the tool is exposed to both thermal and transformation stresses. These stresses will result in distortion. Insufficient levels of machine stock may result in slower than recommended quench rates during heat treatment. To predict maximum levels of distortion with a proper quench, a stress relief is always recommended between rough and semifinished machining, prior to hardening. For a stress relieved Uddeholm Skolvar tool a minimum machining stock of 0.3% is recommended to account for acceptable levels of distortion during a heat treatment with a rapid quench.

MACHINING RECOMMENDATIONS

Softannealed condition

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions. More information can be found in the Uddeholm publication “Cutting data recommendation”.

The recommendations in following tables are valid for Uddeholm Skolvar in soft annealed condition

TURNING

Cutting data parameters	Turning with carbide Rough turning	Turning with carbide Fine turning	Turning with HSS Fine turning
Cutting speed (v_c) m/min f.p.m	130-180 430-590	180-230 590-760	15-20 50-65
Feed (f) mm/r i.p.r	0.2-0.4 0.008-0.016	0.5-2 0.002-0.008	0.05-0.3 0.002-0.012
Depth of cut (a_p) mm inch	2-4 0.08-0.16	0.5-2 0.02-0.08	0.5-3 0-02-0.12
Carbide designation ISO	K20-P20 C7-C6 Coated carbide	K15-P15 C7 Coated carbide of cermet	- -

DRILLING

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm	Drill diameter inch	Cutting speed (V_c) m/min	Cutting speed (V_c) f.p.m	Feed (f) mm/r	Feed (f) i.p.r
-5	-3/16	12-16*	40-52*	0.05-0.15	0.002-0.006
5-10	3/16-3/8	12-16*	40-52*	0.15-0.20	0.006-0.008
10-15	3/8-5/8	12-16*	40-52	0.20-0.25	0.008-0.010
15-20	5/8-3/4	12-16*	40-52*	0.25-0.35	0.010-0.014

** For coated HSS drill v_c ~22-24 m/min (72-79 f.p.m)*

CARBIDE DRILL

Cutting data parameters	Type of drill Indexable insert	Type of drill Solid carbide	Type of drill Carbide tip[1)]
Cutting speed (v_c) m/min f.p.m	150-200 495-660	80-120 260-395	60-90 195-295
Feed (f) mm/r i.p.r	0.03-0.10[2)] 0.001-0.004[2)]	0.10-0.25[3)] 0.004-0.01[3)]	0.15-0.25[4)] 0.006-0.01[4)]

1) Drills with replaceable or brazed carbide tip
2) Feed rate for drill diameter 20-40 mm (0.8”-1.6”)
3) Feed rate for drill diameter 5-20 mm (0.2”-0.8”)
4) Feed rate for drill diameter 10-20 mm (0.4”-0.8”)

MILLING

FACE AND SQUARE SHOULDER MILLING

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m	120-160 390-530	160-200 525-655
Feed (f_z) mm/r i.p.r	0.2-0.4 0.008-0.016)	0.1-0.2 0.004-0.08
Depth of cut (a_p) mm inch	2-4 0.08-0.16	0.5-2 0.02-0.08
Carbide designation ISO US	P20-P40 C6-C5 coated carbide	P10-P20 C7-C6 coated carbide or cermet

END MILLING

Cutting data parameters	Type of milling		
	Solid carbide	Carbide indexable insert	High speed steel[1]
Cutting speed (v_c) m/min f.p.m	100-130 330-430	100-140 330-460	15-20[1] 50-65[1]
Feed (f) mm/r i.p.r	0.01-0.20[2] 0.0004-0.008[2]	0.06-0.20[2] 0.002-0.008[2]	0.01-0.30[2] 0.0004-0.012[2]
Carbide designation ISO US	-	P30 C6-C5	–

1) For coated HSS end mill vc 20-25 m/min (65-85 f.p.m)
2) Depending on radial depth of cut and cutter diameter

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm publication “Grinding of tool steel”

WHEEL RECOMMENDATION

Type of grinding	Annealed condition milling	Hardened condition milling
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 KV	A 120 JV

MACHINING RECOMMENDATIONS

Hardened and tempered condition

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions.

The recommendations in following tables are valid for Uddeholm Skolvar hardened and tempered to 54-58 HRC.

TURNING

Cutting data parameters	Turning with carbide	
	Rough turning	Fine turning
Cutting speed (v_c) m/min f.p.m	40-60 130-200	60-80 200-265
Feed (f) mm/r i.p.r	0.1-0.2 0.004-0.008	0.05-0.1 0.002-0.004
Depth of cut (a_p) mm inch	0.5-2.0 0.02-0.08	0.2-0.5 0.008-0.02
Carbide designation ISO	K10-P10* Coated carbide, CBN	K05, P05-P10* Coated carbide, cermet or CBN

1) Cutting fluid is recommended
2) Avoid CBN at interrupt cutting conditions
3) If using ceramic insert increase cutting speed during interrupt cut

DRILLING

CARBIDE DRILL

Cutting data parameters	Type of drill	
	Solid carbide	Carbide tip[1]
Cutting speed (v_c) m/min f.p.m	30-40 100-130	40-50 130-165
Feed (f) mm/r i.p.r	0.05-0.20[2] 0.002-0.008[2]	0.10-0.20[3] 0.004-0.008[3]

1) Drills with replaceable or brazed carbide tip
2) Feed rate for drill diameter 5-20 mm (0.2"-0.8")
3) Feed rate for drill diameter 10-20 mm (0.4"-0.8")

MILLING

FACE AND SQUARE SHOULDER MILLING

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m	30-50 100-165	50-70 165-230
Feed (f_z) mm/r i.p.r	0.05-0.1 0.002-0.004	0.05-0.1 0.002-0.004
Depth of cut (a_p) mm inch	0.5-1.0 0.02-0.04	0.1-0.5 0.004-0.02
Carbide designation ISO US	P10-P20 K10-K20 C7-C6 coated carbide	P10-P20 C7-C6 coated carbide or cermet

END MILLING

Cutting data parameters	Type of milling	
	Solid carbide	Carbide indexable insert
Cutting speed (v_c) m/min f.p.m	60-80 200-265	40-90 130-300
Feed (f) mm/tooth in/tooth	0.01-0.10[1] 0.0004-0.004[1]	0.05-0.15[1] 0.004-0.008[1]
Carbide designation ISO US	-	P10-20 C6-C5

1) Depending on radial depth of cut and cutter diameter

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm publication “Grinding of tool steel”

WHEEL RECOMMENDATION

Type of grinding	Hardened condition
Face grinding straight wheel	A 46 HV
Face grinding segments	A 36 GV
Cylindrical grinding	A 60 KV
Internal grinding	A 60 IV
Profile grinding	A 120 JV

SURFACE TREATMENTS

Tool steel may be given a surface treatment to reduce friction and increase wear resistance. The most used treatments are nitriding and surface coating (PVD or CVD). Uddeholm Skolvar is suitable as a substrate steel for various surface coatings.

NITRIDING AND NITROCARBURIZING

Nitriding and nitrocarburizing result in a hard surface layer which is very resistant to wear and galling.

DEPTH OF NITRIDING

The thickness of the layer should be chosen to suit the application in question. Example of the depths and hardness that could be achieved after different kind of nitriding operations are shown in the table below. The maximum surface hardness after nitriding is approximately 1100–1320 $HV_{0.2}$

Process	Time (h)	Depth* (mm/inch)	Hardness ($HV_{0.2}$)
Gas nitriding at 520˚C (968˚F)	10	0.10/0.00394	~1170
at 550˚C (1022˚F)	25	0.16/0.0063	~1300
Nitrocarburizing in gas at 570˚C (1058˚F)	1	0,12/0.00472	~1200

** Depth of case = distance from surface where hardness is 50 $HV_{0.2}$ higher than matrix hardness.*

PVD

Physical vapour deposition, PVD, is a method for applying wear-resistant surface coating at temperatures between 200–500°C (390–930°F).

CVD

Chemical vapour deposition, CVD, is a method for applying wear-resistant surface coating at a temperature typically around 1000°C (1830°F).

ELECTRICAL DISCHARGE

MACHINING – EDM

Following the EDM process, the applicable die surfaces are covered with a resolidified layer (white layer) and a rehardened and untempered layer, both of which are very brittle and hence detrimental to die performance. If EDM is used the white layer must be completely removed mechanically by grinding or stoning. After finish-machining the tool should be given an additional temper at approx. 25°C (50°F) below the highest previous tempering temperature. Further information is given in the Uddeholm brochure “EDM of Tool Steel”.

WELDING

Welding of die components can be performed with acceptable results, if the proper precautions are taken during the preparation of the joint, the filler material selection, the pre-heating of the tool, the controlled cooling of the tool and the post weld heat-treatment processes.

The following guidelines summarize the most important welding process parameters.

More detailed information can be found in the brochure “Welding of Tool Steel”.

Welding method	TIG	MMA
Preheating temperaure	330°C ± 25°C 625°F ± 50°F	330°C ± 25°C 625°F ± 50°F
Filler material	UTP A 696 QRO 90 TIG Caldie TIG	UTP 690
Maximum interpass temperature	500°C 940°F	500°C 940°F
Post weld cooling	20-40˚C/h, 35-40˚F/h The first 2 hours, then freely in air <70˚C, 160˚F	
Hardness after welding	54-62 HRC	54-62 HRC
Post weld heat treatment		
Hardened condition	Temper 25°C / 50°F for 2h below previous tempering temperature	
Soft annealed condition	Soft-anneal according to the “heat treatment recommendations”	

FURTHER INFORMATION

Please contact your local Uddeholm office for further information on the selection, heat treatment, application, and availability of Uddeholm tool steel.

Manufacturing solutions for generations to come

SHAPING THE WORLD®

We are shaping the world together with the global manufacturing industry. Uddeholm manufactures steel that shapes products used in our every day life. We do it sustainably, fair to people and the environment. Enabling us to continue shaping the world – today and for generations to come.

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